Mars Exploration Rover

Landing Site Ellipse Update

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3rd MER Landing Site Selection Workshop
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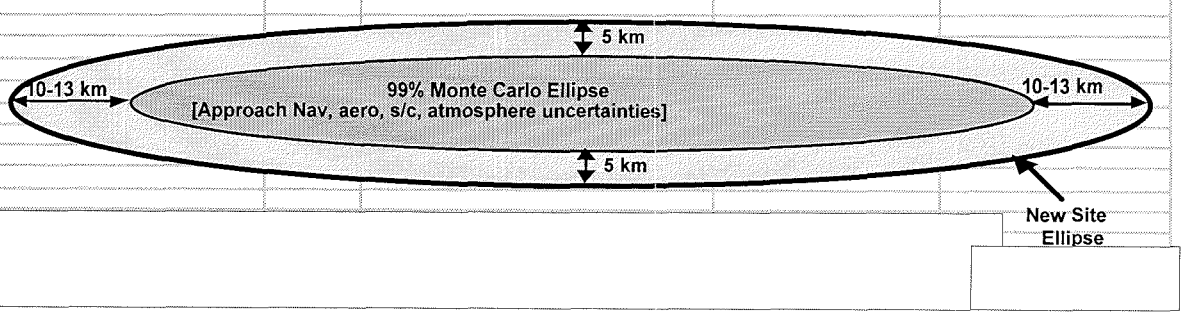
10/2001 Site Ellipse Analyses and Assumptions

- **Entry dispersions were for TCM5 at Entry - 2 days [data cutoff at Entry - 2.5 days]**
  - **Assumes Auto-TCM: designed maneuver instead of library of fixed maneuvers**
- **Approach Nav estimates include ΔDOR and peer-reviewed orbit determination filter inputs**
  - **A "no margin" floor capability was established, then margins were added for Navigation robustness.**
  - **Nav delivery capabilities are strongly dependent on spacecraft dynamics**
    - ACS events, non-grav acceleration uncertainty, maneuver execution error
  - **Nav delivery capabilities do not apply in the event of a thruster failure**
    - Unbalanced turns produce non-zero net ΔV from each ACS event, resulting in degraded performance.
- **LARC 6DOF and/or JPL 3DOF Monte Carlo analyses were performed for all ROTO sites plus Athabasca. 99% landing ellipses were calculated.**
  - **Sets of 2000 entry states were provided at: IP85A, TM10A, VM53A, EP55A, IP98B, TM20B, Melas B Site**
  - **B-plane dispersions generated from these data, plus new nominal entry states, were used to create approximate dispersed states for Monte Carlo analyses at the other ROTO sites.**
  - **Curve fits based on the ROTO site ellipses were used to provide approximate landing ellipse dimensions for the Nadir sites**
- **EDL margins were added to the 99%landing ellipses to account for other potential effects on ellipse dimensions, including:**
  - **Sustained winds, additional atmospheric density dispersions, potential change in target entry flight path angle, etc.**

EDL Margins

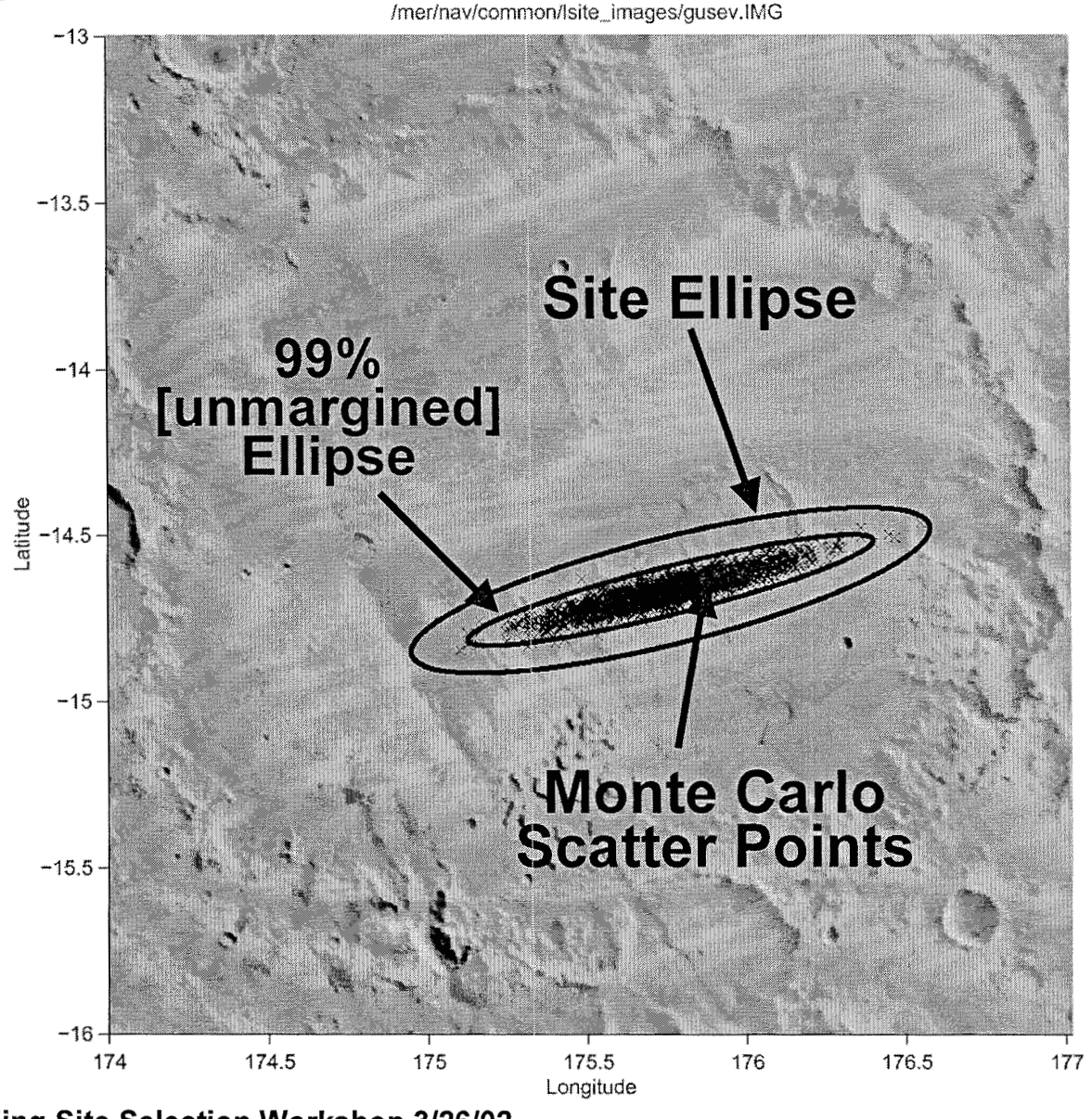
Factor	Factor Value	Rationale	Effect on Total Downtrack [km]	Effect on Total Crosstrack [km]
Sustained Winds	20 m/s	Mesoscale models show winds up to 24 m/s - 30 m/s	4	4
Atmos Density	+/-5%	Dust storm requirement; Additional modeling uncertainty	12	0
Impact to Roll Stop	1 km	Max roll distance [MPF]	1	1
		RSS:	**13**	**4**
Crosstrack Control Limit	5 km	MPL ops experience	0	5
		Subtotal	**13**	**9**
Targeted Entry FPA	-0.2°	Chute load reduction; Reduced angle of attack at chute deploy; Additional atmosphere robustness	10% of Monte Carlo ellipse length	0
EDL Margin added to 99% Monte Carlo Ellipse:			**13 + 10%**	**10**



Total Downtrack EDL Margin is equivalent to an EFPA error of 0.04° - 0.05°

<u>Partial:</u> 5 km Total Downtrack per ±0.01° 3σ EFPA

Gusev Example [10/2001 Site Location]



Nav Update

- Work done for 10/2001 workshop suggested an uncertainty [i.e. noise] of ~ 0.02° in 3σ EFPA errors, based on effects of minor changes to analysis [ΔDOR & Doppler/Range scheduling, etc.]

- Covariance Study comparison with Odyssey approach reconstruction
  - Good agreement - no need to change Orbit Determination filter assumptions

- Further refinement of delivery estimates
  - Revision of TCM-5 maneuver execution errors: 1σ reduced by 1 mm/s [MER-A], 2 mm/s [MER-B]
  - Latest Delivery estimates are at level of 10/2001 numbers or better :

	MER-A							
Landing Site	Isidis Planitia (IP96B)	Hematit (TM10A	Melas Chasma (VM53A	Gusev Crater (EP55A	Isidis Planitia (IP85A)	Hematit (TM10A	Melas Chasma (VM53A	Gusev Crater (EP55A
Day of L. Period	Open	Open	Open	Open	Close	Close	Close	Close
Site Latitude	4.62 N	2.2 S	8.68 S	14.67 S	4.62 N	2.2 S	8.68 S	14.67 S
Site Longitude	85.21	353.23	282.07	175.75	85.21	353.23	282.07	175.75
Inertial Entry Path Angle Er (3σ) 10/2001	±0.23	±0.19	±0.16	±0.14	±0.21	±0.18	±0.15	±0.16
Inertial Entry Path Angle Er (3σ) 2/2002	±0.22	±0.19	±0.14	±0.13	±0.21	±0.17	±0.14	±0.15

	MER-B					
	Isidis Planitia (IP96B)	Hematit (TM20B	Melas Chasma (B Site)	Isidis Planitia (IP96B)	Hematit (TM20B	Melas Chasma (B Site)
	Open	Open	Open	Close	Close	Close
	4.55 N	1.98 S	8.68 S	4.55 N	1.98 S	8.68 S
	84.01 E	353.82 E	282.07 E	84.01 E	353.82 E	282.07 E
	±0.24	±0.19	±0.16	±0.22	±0.17	±0.15
	±0.22	±0.15	±0.12	±0.20	±0.13	±0.12

10/2001 Site Locations

- DSN contention during MER approach phase is high, and may affect quantity of Doppler & Range tracking available for MER.
  - Worst case impact is up to ~0.03° increase in 3σ EFPA error

Updated Landing Error Estimates

- Site locations have changed slightly, with negligible effect on site dimensions
- EDL Margins are unchanged
  - Likelihood of shallowing the targeted entry flight path angle is somewhat lower, depending on results of the parachute deploy strength tests in May 2002
- Updated landing error ellipses [including EDL margin] based on new Nav delivery are slightly smaller:

Site	MER-A Open of Launch Period						MER-A Close of Launch Period					
	Total Downtrack 10/2001 [km]	Total Downtrack (3/2002) [km]	²Downtrack (now-was) [km]	²Downtrack (A-B) [km]	Total Crosstrack 10/2001 [km]	Azimuth 10/2001 [deg.]	Total Downtrack 10/2001 [km]	Total Downtrack (3/2002) [km]	²Downtrack (now-was) [km]	²Downtrack (A-B) [km]	Total Crosstrack 10/2001 [km]	Azimuth 10/2001 [deg.]
Isidis	132	130	-2	-3	16	88	127	126 *	-1 *	2 *	17	85
Hematite	119	117	-2	15	17	84	113	108 *	-5 *	15 *	17	81
Melas	103	95	-8	6	18	80	100	95 *	-5 *	5 *	19	78
Gusev	96	91 *	-5 *	n/a	19	76	103	99 *	-4 *	n/a	19	74

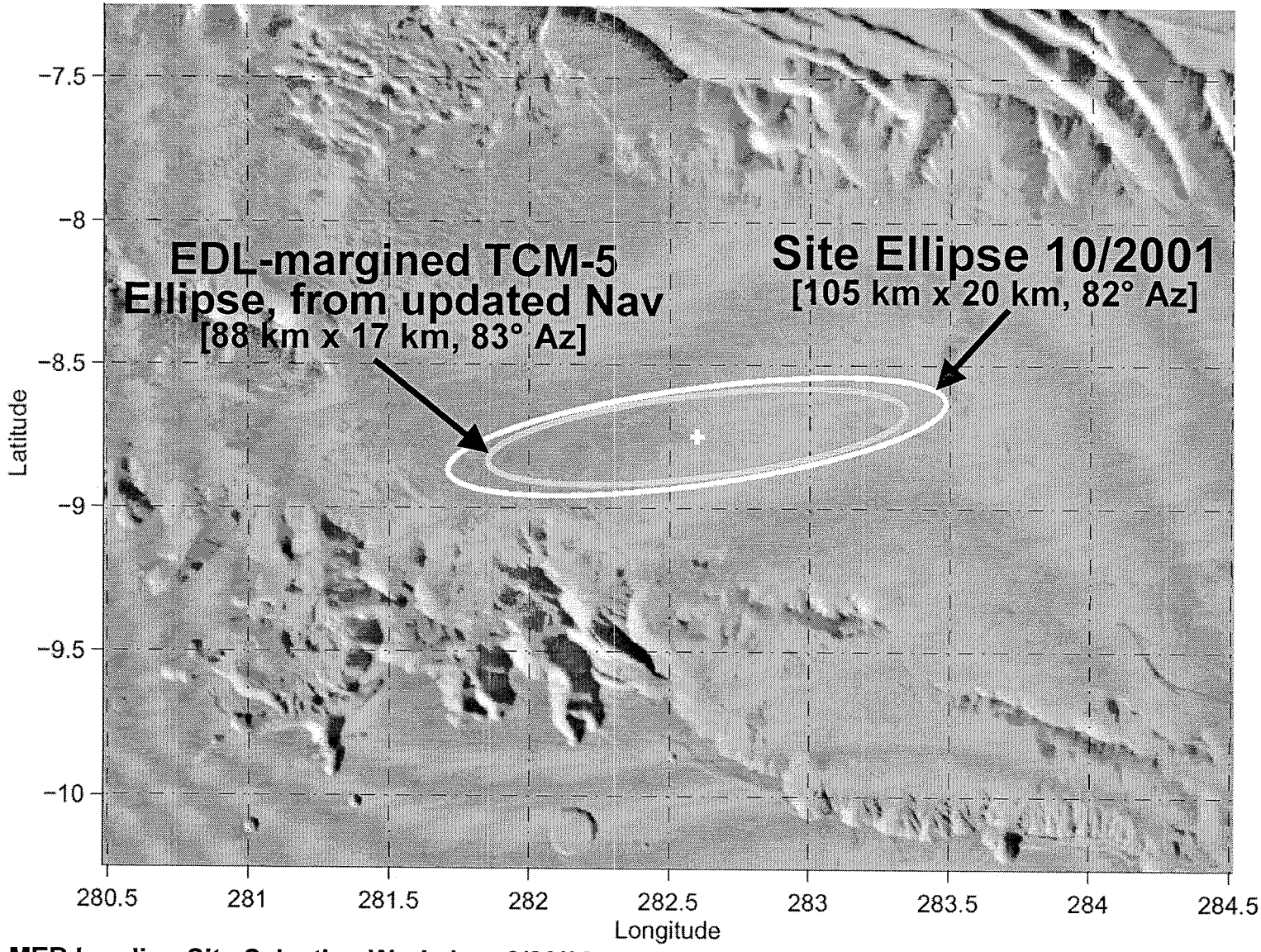
Site	MER-B Open of Launch Period						MER-B Close of Launch Period					
	Total Downtrack 10/2001 [km]	Total Downtrack (3/2002) [km]	²Downtrack (now-was) [km]	²Downtrack (B-A) [km]	Total Crosstrack 10/2001 [km]	Azimuth 10/2001 [deg.]	Total Downtrack 10/2001 [km]	Total Downtrack (3/2002) [km]	²Downtrack (now-was) [km]	²Downtrack (B-A) [km]	Total Crosstrack [km]	Azimuth [deg.]
Isidis	140	134 *	-6 *	3 *	16	91	133	125 *	-8 *	-2 *	17	86
Hematite	117	102 *	-15 *	-15 *	18	86	112	94 *	-18 *	-15 *	19	82
Melas	105	89 *	-16 *	-6 *	20	82	103	90 *	-13 *	-5 *	20	79
Melas		88 **	-17 **	-7 **	18 **	83 **						

* Estimate based on curve fit from 10/2001 and other data

** Based on POST & AEPL Monte Carlos using 2000 entry states generated 3/1/2002.

Melas [MER-B Open]

/mer/nav/common/lsite_images/melas_folder/melas_chasma.IMG



Conclusions

- **No change to the Site Ellipse dimensions are recommended**
  - **New Nav estimates improve 3σ EFPA error by up to ~ 0.04°**
  - **New uncertainties and potential threats are comparable in magnitude**
    - **Analysis "noise" [0.02°]**
    - **Threat to Doppler/Range tracking schedule [≤ 0.03°]**
  - **Other Issues:**
    - **Current analyses assume some ground system infrastructure performance beyond levels previously committed to.**
      - **e.g. Earth orientation parameters, media calibrations, etc.**
    - **Not currently modeled:**
      - **Separation ΔV, HRS venting ΔV**
      - **Operational effects: in-flight anomalies, targeting process, …**